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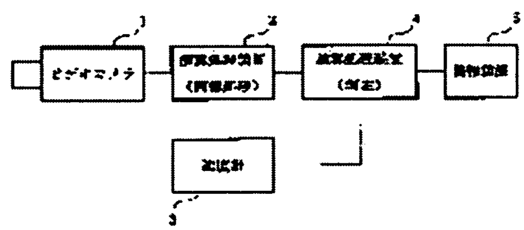
(54) FORWARD MONITORING METHOD FOR VEHICLE

(57)Abstract:
PURPOSE: To judge a degree of danger due to a traveling vehicle and the like in front and other obstacles on the road automatically and at high speed by using a foreground image by a video camera without using a distance sensor for measuring an inter-vehicle distance to the preceding vehicle.



CONSTITUTION: Movement of the same point on an object shown in two frames of images chronologically continuing in a series of foreground animations is detected as an optical flow vector, and danger is judged by its size. A narrow window set in the radical direction from FOE of the previous image is moved in the same direction on the successive image, and the optical flow vector of a point to be aimed at is set as an arrow connecting each of the central points of the position of the window where the sum of absolute values of difference in brightness of the area on the successive image that the window overlaps the window becomes the minimum, and the set position of the window in the previous image. However, the point to obtain the optical flow is the only point that the difference in brightness between the previous and successive images exceeds a certain threshold value so that influence of landscape outside the road or a traffic lane, letters or characters drawn on the road should be eliminated in obtaining the optical flow.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the front monitor approach for cars for detecting a front car or a front obstruction in the case of transit of a car, and giving an operator warning using the image picturized with the video camera installed in the anterior part of cars, such as an automobile.
[0002]
[Description of the Prior Art] Conventionally, there are some which were indicated by for example, the Japanese-Patent-Application-No. No. 241855 [two to] official report as this kind of an approach. The approach indicated by this official report photos a foreground from the self-car it is running, recognizes migration of the same point of this photoed foreground as an optical flow for every predetermined time, acquires the information which consists of a location of the precedence car to a self-car, and relative velocity based on the distance robot which measures the distance between two cars of this optical flow and a front car, and when this information is judged to be dangerous on a basis, it tells an operator about that.
[0003] Moreover, in order to ask for an optical flow, the technique called the matching method which detects a point between the images of two coma was adopted conventionally. As this matching method takes an aperture W1 to the pixel P which pays its attention on the image in t the time of being shown in drawing 9 (a), and it calculates a correlation value, moving an aperture to the whole region in an image, or a surrounding field and it is shown in drawing 9 (b), the point of an aperture W2 that the correlation value became max is searched for as corresponding points Q, i.e., a corresponding pixel, and this PQ (arrow head) serves as an optical flow. In order to calculate the above-mentioned correlation value sigma(W1 (x y) xW2 (x y))/(sigmaW12 (x y)xsigmaW22 (x y))1/2 .... (1)
Becoming count is performed. In addition, W1 (x y) and W2 (x y) It is the output of the coordinate (x y) in an aperture W1 and W2.
[0004]
[Problem(s) to be Solved by the Invention] However, by such conventional approach, in addition to the video camera which photos a foreground in order to judge risk, in order to know the location of the precedence car to a self-car, the distance robot for measuring the distance between two cars with a front car is also needed for coincidence.
[0005] Moreover, as mentioned above, in order that it is necessary to perform data

processing of detecting a point between the images of two sheets but in order to ask for an optical flow, and this data processing may detect a certain corresponding points of one point, it is said to 1 pixel of an image that it searches to all the pixels of all the fields in an image, or a surrounding field. In order to detect corresponding points over the whole image, this processing must be performed to all pixels. Moreover, many count is needed also in order to calculate the correlation value used as an index in order to search.

[0006] Therefore, since a processing unit high-speed in order real-time-izing is difficult since computational complexity becomes huge, or to realize is needed, the problem that equipment itself will form an expensive rank is raised. Moreover, the trouble that it is difficult to distinguish that it will not be generated from the part of a precedence car and that the optical flow will arise neither from an alphabetic character, nor a notation or a white line on the scenery outside a road or a road surface is also got.

[0007] Therefore, this invention aims at offering the front monitor approach for cars of having enabled it to judge automatically the danger by a front transit car and other front obstructions, using the foreground image from the video camera installed in car anterior part, without measuring the distance between precedence cars in view of the conventional trouble mentioned above.

[0008] Moreover, this invention aims at offering the front monitor approach for cars of having enabled it to recognize migration of the same point at a high speed as an optical flow for every predetermined time in the foreground picturized with the video camera.

[0009]

[Means for Solving the Problem] The front monitor approach for cars made by this invention in order to attain the above-mentioned purpose Picturize a foreground from the self-car it is running, and it recognizes as an optical flow based on the image of two coma which carries out migration of the same point of this picturized foreground before and after a predetermined time phase. In the front monitor approach for cars which supervises the precedence car or obstruction to a self-car based on this optical flow, it is characterized by judging danger with the magnitude of said optical flow of the point of said precedence car or a failure lifter.

[0010] The long and slender aperture centering on one of them is set up in the direction of a radial to one point noted from the infinite point corresponding to one point which shows the travelling direction of the self-car it is running in the above-mentioned front monitor approach for cars in the image of before in the image of two coma carried out before and after a predetermined time phase. It is characterized by asking for total of the absolute value of a brightness difference with the aperture in the image of said front, and asking as an optical flow of one point which pays its attention to the movement magnitude of an aperture when this total becomes min, moving this aperture in the radiation direction from said infinite point in a next screen.

[0011] In the above-mentioned front monitor approach for cars, it is characterized by searching for a brightness difference by the image of two coma carried out before and after a predetermined time phase, and asking for an optical flow about the point beyond a fixed threshold with this brightness difference.

[0012] In asking for an optical flow, in the above-mentioned front monitor approach for cars, it is characterized by removing the optical flow produced from the scenery

outside a road, the lane of a road surface, an alphabetic character, a notation, etc.
[0013] In asking for an optical flow, the field equivalent to the scenery outside a road is set up beforehand, and it is characterized by not processing the this set-up field.
[0014] It has the video camera which picturizes a foreground from the self-car it is running, the height from the lane on the road surface which the optical flow has produced based on optical flow information, an alphabetic character, a notation, etc. to a video camera is found, and this height is characterized by removing the optical flow which is in agreement with the height of the camera from a road surface.
[0015] The field appointed beforehand is divided into two or more areas, weighting is carried out for every area to total of the die length of the optical flow vector which exists in each area, and it is characterized by judging the degree of risk with this value that carried out weighting.
[0016] A predetermined threshold is set up for every area and it is characterized by judging the area where said total of optical flow vector die length by which weighting was carried out exceeded this threshold to be dangerous.
[0017] Said threshold consists of number level and it is characterized by judging the level of danger with the level of the threshold which said total of optical flow die length by which weighting was carried out exceeded.
[0018] It is characterized by emitting an alarm according to the magnitude of the danger searched for.
[0019]
[Function] Since he is trying to judge risk paying attention to an OPUI cull flow becoming large with the magnitude of the optical flow of the point of a precedence car or a failure lifter on the street so that relative velocity is so large that distance with a precedence car or an obstruction is small according to the above-mentioned approach, it is unnecessary to form the range finder for measuring the distance between precedence cars exceptionally.
[0020] An optical flow sets in the image of the front of the images of two coma paying attention to being formed in the direction of a radial from the infinite point corresponding to one point which shows the travelling direction of a self-car. Setting up a long and slender aperture in the direction of a radial to one point to note from the infinite point corresponding to one point which shows the travelling direction of the self-car it is running, and moving this aperture in the radiation direction from said infinite point in a next screen It asks for total of the absolute value of a brightness difference with the field of the image after lapping with the aperture and this aperture in an image of said front. Since he is trying to determine the arrow head which connects between each central point of the location of an aperture when this total becomes min, and the setting location in the image in front of this aperture as the optical flow of one point, it becomes mitigation of computational complexity and processing can be accelerated.
[0021] since a brightness difference be search for paying attention to there be a location which do not have time brightness change like the empty include in an image or a road surface by the image of two coma carry out before and after a predetermined time phase and he be try to ask for an optical flow about the point beyond a fixed threshold with this brightness difference , the number of the points in the image which ask for an optical flow decrease sharply , and can accelerate by become possible to exclude useless processing .

[0022] In order to remove the optical flow produced from the scenery outside a transit schedule lane in asking for an optical flow, the field equivalent to the scenery outside a transit schedule lane is set up beforehand, and since it is made not to process the this set-up field, the processing time is accelerable.
[0023] The lane and alphabetic character on the road surface which was equipped with the video camera which picturizes a foreground from the self-car it is running, and the optical flow has produced using optical flow information, By finding the height from a notation etc. to a video camera, and removing the optical flow this whose height corresponds with the height of the camera from a road surface Only the optical flow produced only from the vehicle besides the front and the obstruction can be processed, and the processing time is accelerable while becoming possible to get to know danger using an optical flow.
[0024] Since the field appointed beforehand is divided into two or more areas, weighting is carried out for every area to total of the die length of the optical flow which exists in each area and existence of risk is judged with this value that carried out weighting, it can know in which location risk is. Moreover, a predetermined threshold is set up for every area, the area where total of optical flow vector die length exceeded this threshold is judged to be dangerous, and sweet red bean soup with mochi can do danger for every area. Furthermore, a threshold consists of number level, and he judges the level of danger with the level of the threshold which total of optical flow vector die length exceeded, and is trying to emit an alarm according to the magnitude of the danger searched for.
[0025]
[Example] Hereafter, the example of this invention is explained based on a drawing. Drawing 1 shows the configuration of the equipment for enforcing the approach by this invention, the video camera with which 1 picturizes a foreground in this drawing, and 2 input the image obtained with the video camera 1, and the processing unit which performs the image processing mentioned later, the speedometer with which 3 measures the rate of a self-car, the processing unit which 4 inputs the image-processing result of a processing unit 2 and the self-car rate obtained from a speedometer 3, and performs danger judging processing, and 5 are alarms.
[0026] Drawing 2 is drawing for explaining change of the foreground image obtained with a video camera 1, and the image which the video camera 1 picturized by time amount t in the situation containing the self-car which shows (b) to (a), and the image which picturized (c) by time amount t+delta t are shown, respectively.
[0027] Now, a self-car presupposes that the flat path is gone straight on. For example, if the road sign and building which are shown in (a) are observed, an image as shown in (b) and (c) in time amount t and time amount t+delta t by the passage of time will be obtained. If they are connected in search of the point of corresponding in this image of two sheets, a velocity vector as shown in (d) will be obtained. This is an optical flow.
[0028] These optical flows appear in a radial from one point called FOE in an image (Focus of Expansion) here. It corresponds to one point which shows the travelling direction of a self-car on an image in FOE when it is called an infinite point or a vanishing point and the car is going straight on. Thus, the optical flow called for when the self-car is running is the direction of FOE to a radial. The optical flow emitted from the precedence car here includes the information which consists of a location of

the precedence car to a self-car, and relative velocity, and it is considered that danger is high, so that an optical flow is long.
[0029] Next, the detail is explained with reference to drawing 3 . optical arrangement of this drawing -- if it is and 11 considers as the lens of a video camera, and the point corresponding to [12 / f / the image plane of a video camera, and / corresponding to one point of the arbitration of a precedence car or a failure lifter in the distance from the lens 11 to the image plane 12, and P (X, Y, Z)] the point P on the image plane 12 in p (x y) -- from the ratio of similarity of three square shapes x=f-X/Z .... (2)
It becomes.
[0030] If this formula is transformed and time amount differential is carried out X'= (deltax/deltat-Z+x-Z')/f .... (3)
It becomes. Moreover, the x direction components u of an optical flow U=deltax/deltat .... (4)
It comes out, and since it is, this is used. Z=(f-X' - x-Z')/u .... (5)
It becomes.
[0031] Here Relative velocity of a Z'= precedence car thru/or an obstruction and a self-car = -alpha .... (6)
Since come out and it is, it is an upper type (5). Z=(f-X'+xalpha)/u .... (7)
It becomes. Therefore, the x direction components u of an optical flow u=(f-X'+xalpha)/Z .... (8)
It becomes. It can be similarly found about Y.
[0032] Therefore, from a top type (8), as for x components of an optical flow, the relative velocity of size, i.e., a precedence car, becomes large so that Z is [the distance to smallness, i.e., a precedence car, or an obstruction] smallness, or, so that alpha is size. This is the same also about the direction of Y. Therefore, an optical flow becomes so long that so size [relative velocity] still that it is **** in distance with a precedence car etc., and the direction when longer than the time when an optical flow is shorter than this is considered that the danger over a precedence car or an obstruction is relatively large.
[0033] By this invention, use that the sense of a radial is asked for an optical flow from FOE, he is trying to ask a high speed for an optical flow, and the approach is explained below based on drawing 4 .
[0034] Drawing 4 is drawing having shown one example of the approach of asking a high speed for an optical flow. First, a long and slender aperture is set up in the direction of a radial from FOE to one point first noted in the image in time amount t (drawing 4 (a)). Next, it asks for total of the absolute value of a brightness difference with the aperture in time amount t in the image in time amount t+delta t, moving an aperture one point at a time in the direction of a radial from FOE. And the movement magnitude of an aperture when total becomes min is calculated as a velocity vector of one point to which its attention is paid (drawing 4 (b)). In addition, the above-mentioned brightness difference is a thing between the pixels of the corresponding location shown in (a) and (b) by O about each pixel which constitutes an aperture. It can ask for the optical flow of the whole image by performing the above processings repeatedly in all the points of the image of time amount t.
[0035] Moreover, by the conventional approach, when corresponding apertures were compared, the cross-correlation value was used. Since total of the absolute value of a brightness difference is used by the approach of this invention to it, it becomes

mitigation of computational complexity and processing can be accelerated.
[0036] Further, it is asking for the velocity vector from not all the points in an image, and a difference is searched for and it is made to process by the image of time amount t and time amount t+delta t in this invention only to the point beyond the fixed threshold which is the difference.
[0037] Generally, the image which projected the foreground during car transit has many locations which do not have a time brightness change like empty or a road surface. Asking for an optical flow theoretically is impossible in such a location. Therefore, like the approach of this invention, within the image in time amount t, and the image in time amount t+delta t, if it is, it is accelerable by becoming possible to exclude useless processing by [which is a brightness difference] processing paying attention to things.
[0038] A high speed is asked for an optical flow by approach which was mentioned above. However, the optical flow produced by what is not obstructions, such as scenery other than a road and a lane of a road surface, is contained in the optical flow which was able to be found here. Therefore, it is difficult to search for the danger by existence of a front obstruction or its obstruction using the optical flow currently called for here. Therefore, it is necessary to remove the optical flow produced from the scenery outside a road, or the lane of a road surface. Next, this approach is explained.
[0039] Drawing 5 is one example of the approach of removing the optical flow by the scenery outside a road. The location where the slash is drawn in this drawing shall not process in the other location noting that it shows a path on the street. by carrying out like this, since it begins, the optical flow produced from the scenery outside a road cannot be found -- ******** -- in addition -- and the processing time can be accelerated by restricting a field.
[0040] Next, how to erase the mark on a road surface is explained using drawing. Drawing 6 is one example of this approach, and explains an optical configuration first. Drawing 6 is drawn instead of the car which installed the video camera going straight on, assuming that the whole road surface has approached. The lens of the video camera with which 11 picturizes the front, and 12 show the image plane of a video camera. 13 and 14 express the lane before and behind migration. The three-dimension coordinate which makes the core of a lens a zero, and the two-dimensional coordinate which makes Above FOE a zero on the image plane 2 are considered.
[0041] The height to the video camera of the lane where the optical flow has produced the location of the lane before migration like [similitude ratio / of two square shapes / three] a formula (1) in P (X, Y, Z+deltaZ) and a Z direction if the location after deltaZ migration is set to Q (X, Y, Z) can be known.
Y=y2 delta Z/fdeltay .... (9)
The optical flow which height is in agreement with video camera quantity, that is, has produced by the mark on a road surface etc. is removable using this height information that was able to be found.
[0042] Here, deltaZ is the distance which advanced between time interval deltat of the image of two sheets, and it can ask for it by getting to know a car rate. It becomes possible to remove the optical flow produced from other than the front obstruction by processing which was explained above. Therefore, a front obstruction becomes possible [searching for the danger which shows how much it is risk] from the location and die length of the optical flow left behind now.

[0043] Next, how to search for danger is explained. Drawing 7 shows one example of this approach. If a configuration is explained first, each field of I -IV shows the distant place of a self-lane, the method of Kon of a self-lane, the distant place of a next door lane, and the method of Kon of a next door lane, respectively. Weighting of the danger is carried out for every area to total of the die length of the optical flow which exists in each field, and it is searched for here with this value that carried out weighting. Furthermore, the predetermined threshold is set up for every field, and if total of flow die length exceeds this threshold, it will be judged that the field beyond a threshold is dangerous. Number level setting of the threshold is carried out, and the level of danger can also be judged.

[0044] It becomes possible to be able to demand cautions from an operator by sounding an alarm at the end according to the magnitude of the danger searched for. Moreover, it also enables which field to indicate whether how many to be risk on a display. It is also possible to change classes, such as a tone of an alarm, with risk level furthermore.

[0045] If the procedure of the image processing by the approach of this invention explained above is summarized and shown, it will become like drawing 8 . First, the image in time amount t is captured in step S1, and then the image in time amount t+delta t is captured in step S2. After that, FOE is set up in step S3 and a processing field is set up in continuing step S4. Then, it progresses to step S5 and the field where the brightness difference exceeded the fixed threshold by the image of time amount t and time amount t+delta t here is extracted. It asks for an optical flow in the field progressed and extracted to step S6 after that, an optical flow path on the street is removed in the following step S7, and danger is calculated with the value which carried out weighting for every area in the following step S8 further.

[0046]

[Effect of the Invention] Since existence of a forward cardiac failure theory object or its danger can be automatically judged according to this invention as explained above, a safety operation of a car is attained.

[0047] The video camera which picturizes a foreground from the self-car judges risk with the magnitude of the optical flow of the point of a precedence car or a failure lifter, and it is making and running especially is installed ahead [one set], and since it is unnecessary to form the range finder for measuring the distance between precedence cars exceptionally, it is realizable by low cost.

[0048] Moreover, by limit of an abbreviation and a processing field etc., improvement in the speed of processing can perform mitigation of computational complexity, and useless processing, and real-time processing becomes easy about them.

[0049] Furthermore, a hazard area and its degree are got to know, and the effectiveness of being able to emit a suitable alarm is acquired.

[Translation done.]

CLAIMS

[Claim(s)]
[Claim 1] In the front monitor approach for cars which picturizes a foreground from the self-car it is running, detects migration of the same point in the image of two coma carried out before and after a predetermined time phase as an optical flow, and supervises the relative relation between the precedence car to a self-car, or an obstruction on the street The front monitor approach for cars characterized by the thing of the size of the vector of the optical flow which appears to the point of said precedence car or a failure lifter on the street, and an appearance location for which danger is therefore judged how.
[Claim 2] From the infinite point corresponding to one point which shows the travelling direction of the self-car it is running in the image of the front of the images of two coma carried out before and after a predetermined time phase Setting up a long and slender aperture in the direction of a radial, and moving this aperture in the radiation direction from said infinite point in a next image to one point to note It asks for total of the absolute value of a brightness difference with the field of the image after lapping with the aperture and this aperture in an image of said front. The front monitor approach for cars according to claim 1 characterized by determining the arrow head which connects between each central point of the location of an aperture when this total becomes min, and the setting location in the image in front of this aperture as the optical flow of one point.
[Claim 3] The front monitor approach for cars according to claim 1 characterized by searching for the brightness difference of each point between the images of two coma carried out before and after a predetermined time phase, and asking for an optical flow only about the point exceeding a fixed threshold with this brightness difference.
[Claim 4] The front monitor approach for cars according to claim 1 characterized by removing the optical flow produced from the lane which was drawn on the scenery outside a road, or a road surface in asking for an optical flow, an alphabetic character, a notation, etc.
[Claim 5] The front monitor approach for cars according to claim 1 characterized by setting up beforehand the field equivalent to the scenery outside a transit schedule lane in asking for an optical flow, and not processing the this set-up field.
[Claim 6] The front monitor approach for cars according to claim 4 that it has the video camera which picturizes a foreground from the self-car it is running, the height from the lane on the road surface which the optical flow has produced based on optical flow information, an alphabetic character, a notation, etc. to a video camera is found,

and this height is characterized by removing the optical flow which is in agreement with the height of the camera from a road surface.
[Claim 7] The front monitor approach for cars according to claim 1 characterized by dividing into two or more areas the field appointed beforehand, carrying out weighting for every area to total of the die length of the optical flow vector which exists in each area, and judging the degree of risk by the size of this value by which weighting was carried out.
[Claim 8] The front monitor approach for cars according to claim 7 characterized by judging the area where the predetermined threshold was set up for every area, and total of the die length of said optical flow exceeded this threshold to be dangerous.
[Claim 9] The front monitor approach for cars according to claim 8 characterized by judging the level of danger with the level of the threshold which total of the die length of said optical flow exceeded by said threshold consisting of number level.
[Claim 10] The front monitor approach for cars according to claim 9 characterized by emitting an alarm according to the magnitude of the danger searched for.

[Translation done.]

TECHNICAL FIELD

[Industrial Application] This invention relates to the front monitor approach for cars for detecting a front car or a front obstruction in the case of transit of a car, and giving an operator warning using the image picturized with the video camera installed in the anterior part of cars, such as an automobile.

[Translation done.]

PRIOR ART

[Description of the Prior Art] Conventionally, there are some which were indicated by for example, the Japanese-Patent-Application-No. No. 241855 [two to] official report as this kind of an approach. The approach indicated by this official report photos a foreground from the self-car it is running, recognizes migration of the same point of this photoed foreground as an optical flow for every predetermined time, acquires the information which consists of a location of the precedence car to a self-car, and relative velocity based on the distance robot which measures the distance between two cars of this optical flow and a front car, and when this information is judged to be dangerous on a basis, it tells an operator about that.
[0003] Moreover, in order to ask for an optical flow, the technique called the matching method which detects a point between the images of two coma was adopted conventionally. As this matching method takes an aperture W1 to the pixel P which pays its attention on the image in t the time of being shown in drawing 9 (a), and it calculates a correlation value, moving an aperture to the whole region in an image, or a surrounding field and it is shown in drawing 9 (b), the point of an aperture W2 that the correlation value became max is searched for as corresponding points Q, i.e., a corresponding pixel, and this PQ (arrow head) serves as an optical flow. In order to calculate the above-mentioned correlation value sigma(W1 (x y) xW2 (x y))/ (sigmaW12 (x y)xsigmaW22 (x y))1/2 .... (1)
Becoming count is performed. In addition, W1 (x y) and W2 (x y) It is the output of the coordinate (x y) in an aperture W1 and W2.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] Since existence of a forward cardiac failure theory object or its danger can be automatically judged according to this invention as explained above, a safety operation of a car is attained.
[0047] The video camera which picturizes a foreground from the self-car judges risk with the magnitude of the optical flow of the point of a precedence car or a failure lifter, and it is making and running especially is installed ahead [one set], and since it is unnecessary to form the range finder for measuring the distance between precedence cars exceptionally, it is realizable by low cost.
[0048] Moreover, by limit of an abbreviation and a processing field etc., improvement in the speed of processing can perform mitigation of computational complexity, and useless processing, and real-time processing becomes easy about them.
[0049] Furthermore, a hazard area and its degree are got to know, and the effectiveness of being able to emit a suitable alarm is acquired.

[Translation done.]

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[0047] The video camera which picturizes a foreground from the self-car judges risk with the magnitude of the optical flow of the point of a precedence car or a failure lifter, and it is making and running especially is installed ahead [one set], and since it is unnecessary to form the range finder for measuring the distance between precedence cars exceptionally, it is realizable by low cost.
[0048] Moreover, by limit of an abbreviation and a processing field etc., improvement in the speed of processing can perform mitigation of computational complexity, and useless processing, and real-time processing becomes easy about them.
[0049] Furthermore, a hazard area and its degree are got to know, and the effectiveness of being able to emit a suitable alarm is acquired.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] However, by such conventional approach, in addition to the video camera which photos a foreground in order to judge risk, in order to know the location of the precedence car to a self-car, the distance robot for measuring the distance between two cars with a front car is also needed for coincidence.
[0005] Moreover, as mentioned above, in order that it is necessary to perform data processing of detecting a point between the images of two sheets but in order to ask for an optical flow, and this data processing may detect a certain corresponding points of one point, it is said to 1 pixel of an image that it searches to all the pixels of all the fields in an image, or a surrounding field. In order to detect corresponding points over the whole image, this processing must be performed to all pixels. Moreover, many count is needed also in order to calculate the correlation value used as an index in order to search.
[0006] Therefore, since a processing unit high-speed in order real-time-izing is difficult since computational complexity becomes huge, or to realize is needed, the problem that equipment itself will form an expensive rank is raised. Moreover, the trouble that it is difficult to distinguish that it will not be generated from the part of a precedence car and that the optical flow will arise neither from an alphabetic character, nor a notation or a white line on the scenery outside a road or a road surface is also got.
[0007] Therefore, this invention aims at offering the front monitor approach for cars of having enabled it to judge automatically the danger by a front transit car and other front obstructions, using the foreground image from the video camera installed in car anterior part, without measuring the distance between precedence cars in view of the conventional trouble mentioned above.
[0008] Moreover, this invention aims at offering the front monitor approach for cars of having enabled it to recognize migration of the same point at a high speed as an optical flow for every predetermined time in the foreground picturized with the video camera.

[Translation done.]

MEANS

[Means for Solving the Problem] The front monitor approach for cars made by this invention in order to attain the above-mentioned purpose Picturize a foreground from the self-car it is running, and it recognizes as an optical flow based on the image of two coma which carries out migration of the same point of this picturized foreground before and after a predetermined time phase. In the front monitor approach for cars which supervises the precedence car or obstruction to a self-car based on this optical flow, it is characterized by judging danger with the magnitude of said optical flow of the point of said precedence car or a failure lifter.
[0010] The long and slender aperture centering on one of them is set up in the direction of a radial to one point noted from the infinite point corresponding to one point which shows the travelling direction of the self-car it is running in the above-mentioned front monitor approach for cars in the image of before in the image of two coma carried out before and after a predetermined time phase. It is characterized by asking for total of the absolute value of a brightness difference with the aperture in the image of said front, and asking as an optical flow of one point which pays its attention to the movement magnitude of an aperture when this total becomes min, moving this aperture in the radiation direction from said infinite point in a next screen.
[0011] In the above-mentioned front monitor approach for cars, it is characterized by searching for a brightness difference by the image of two coma carried out before and after a predetermined time phase, and asking for an optical flow about the point beyond a fixed threshold with this brightness difference.
[0012] In asking for an optical flow, in the above-mentioned front monitor approach for cars, it is characterized by removing the optical flow produced from the scenery outside a road, the lane of a road surface, an alphabetic character, a notation, etc.
[0013] In asking for an optical flow, the field equivalent to the scenery outside a road is set up beforehand, and it is characterized by not processing the this set-up field.
[0014] It has the video camera which picturizes a foreground from the self-car it is running, the height from the lane on the road surface which the optical flow has produced based on optical flow information, an alphabetic character, a notation, etc. to a video camera is found, and this height is characterized by removing the optical flow which is in agreement with the height of the camera from a road surface.
[0015] The field appointed beforehand is divided into two or more areas, weighting is carried out for every area to total of the die length of the optical flow vector which exists in each area, and it is characterized by judging the degree of risk with this value that carried out weighting.

[0016] A predetermined threshold is set up for every area and it is characterized by judging the area where said total of optical flow vector die length by which weighting was carried out exceeded this threshold to be dangerous.
[0017] Said threshold consists of number level and it is characterized by judging the level of danger with the level of the threshold which said total of optical flow die length by which weighting was carried out exceeded.
[0018] It is characterized by emitting an alarm according to the magnitude of the danger searched for.

[Translation done.]

OPERATION

[Function] Since he is trying to judge risk paying attention to an OPUI cull flow becoming large with the magnitude of the optical flow of the point of a precedence car or a failure lifter on the street so that relative velocity is so large that distance with a precedence car or an obstruction is small according to the above-mentioned approach, it is unnecessary to form the range finder for measuring the distance between precedence cars exceptionally.
[0020] An optical flow sets in the image of the front of the images of two coma paying attention to being formed in the direction of a radial from the infinite point corresponding to one point which shows the travelling direction of a self-car, Setting up a long and slender aperture in the direction of a radial to one point to note from the infinite point corresponding to one point which shows the travelling direction of the self-car it is running, and moving this aperture in the radiation direction from said infinite point in a next screen It asks for total of the absolute value of a brightness difference with the field of the image after lapping with the aperture and this aperture in an image of said front. Since he is trying to determine the arrow head which connects between each central point of the location of an aperture when this total becomes min, and the setting location in the image in front of this aperture as the optical flow of one point, it becomes mitigation of computational complexity and processing can be accelerated.
[0021] since a brightness difference be search for paying attention to there be a location which do not have time brightness change like the empty include in an image or a road surface by the image of two coma carry out before and after a predetermined time phase and he be try to ask for an optical flow about the point beyond a fixed threshold with this brightness difference , the number of the points in the image which ask for an optical flow decrease sharply , and can accelerate by become possible to exclude useless processing .
[0022] In order to remove the optical flow produced from the scenery outside a transit schedule lane in asking for an optical flow, the field equivalent to the scenery outside a transit schedule lane is set up beforehand, and since it is made not to process the this set-up field, the processing time is accelerable.
[0023] While becoming possible to be able to process only the optical flow produced only from the vehicle besides the front, and the obstruction by having the video camera which picturizes a foreground from the self-car it is running, finding the height from the lane on the road surface which the optical flow has produced using optical flow information, an alphabetic character, a notation, etc. to a video camera, and

removing the optical flow this whose height corresponds with the height of the camera from a road surface, and to get to know danger using an optical flow The processing time is accelerable.
[0024] Since the field appointed beforehand is divided into two or more areas, weighting is carried out for every area to total of the die length of the optical flow which exists in each area and existence of risk is judged with this value that carried out weighting, it can know in which location risk is. Moreover, a predetermined threshold is set up for every area, the area where total of optical flow vector die length exceeded this threshold is judged to be dangerous, and sweet red bean soup with mochi can do danger for every area. Furthermore, a threshold consists of number level, and he judges the level of danger with the level of the threshold which total of optical flow vector die length exceeded, and is trying to emit an alarm according to the magnitude of the danger searched for.

[Translation done.]

EXAMPLE

[Example] Hereafter, the example of this invention is explained based on a drawing. Drawing 1 shows the configuration of the equipment for enforcing the approach by this invention, the video camera with which 1 picturizes a foreground in this drawing, and 2 input the image obtained with the video camera 1, and the processing unit which performs the image processing mentioned later, the speedometer with which 3 measures the rate of a self-car, the processing unit which 4 inputs the image-processing result of a processing unit 2 and the self-car rate obtained from a speedometer 3, and performs danger judging processing, and 5 are alarms.
[0026] Drawing 2 is drawing for explaining change of the foreground image obtained with a video camera 1, and the image which the video camera 1 picturized by time amount t in the situation containing the self-car which shows (b) to (a), and the image which picturized (c) by time amount t+delta t are shown, respectively.
[0027] Now, a self-car presupposes that the flat path is gone straight on. For example, if the road sign and building which are shown in (a) are observed, an image as shown in (b) and (c) in time amount t and time amount t+delta t by the passage of time will be obtained. If they are connected in search of the point of corresponding in this image of two sheets, a velocity vector as shown in (d) will be obtained. This is an optical flow.
[0028] These optical flows appear in a radial from one point called FOE in an image (Focus of Expansion) here. It corresponds to one point which shows the travelling direction of a self-car on an image in FOE when it is called an infinite point or a vanishing point and the car is going straight on. Thus, the optical flow called for when the self-car is running is the direction of FOE to a radial. The optical flow emitted from the precedence car here includes the information which consists of a location of the precedence car to a self-car, and relative velocity, and it is considered that danger is high, so that an optical flow is long.
[0029] Next, the detail is explained with reference to drawing 3 . optical arrangement of this drawing -- if it is and 11 considers as the lens of a video camera, and the point corresponding to [12 / f / the image plane of a video camera, and / corresponding to one point of the arbitration of a precedence car or a failure lifter in the distance from the lens 11 to the image plane 12, and P (X, Y, Z)] the point P on the image plane 12 in p (x y) -- from the ratio of similarity of three square shapes x=f-X/Z .... (2)
It becomes.
[0030] If this formula is transformed and time amount differential is carried out X'=(deltax/deltat-Z+x-Z')/f .... (3)

It becomes. Moreover, the x direction components u of an optical flow U=deltax/deltat .... (4)
It comes out, and since it is, this is used. Z=(f-X' - x-Z')/u .... (5)
It becomes.
[0031] Here Relative velocity of a Z'= precedence car thru/or an obstruction and a self-car = -alpha .... (6)
Since come out and it is, it is an upper type (5). Z=(f-X'+xalpha)/u .... (7)
It becomes. Therefore, the x direction components u of an optical flow u=(f-X'+xalpha)/Z .... (8)
It becomes. It can be similarly found about Y.
[0032] Therefore, from a top type (8), as for x components of an optical flow, the relative velocity of size, i.e., a precedence car, becomes large so that Z is [the distance to smallness, i.e., a precedence car, or an obstruction] smallness, or, so that alpha is size. This is the same also about the direction of Y. Therefore, an optical flow becomes so long that so size [relative velocity] still that it is **** in distance with a precedence car etc., and the direction when longer than the time when an optical flow is shorter than this is considered that the danger over a precedence car or an obstruction is relatively large.
[0033] By this invention, use that the sense of a radial is asked for an optical flow from FOE, he is trying to ask a high speed for an optical flow, and the approach is explained below based on drawing 4 .
[0034] Drawing 4 is drawing having shown one example of the approach of asking a high speed for an optical flow. First, a long and slender aperture is set up in the direction of a radial from FOE to one point first noted in the image in time amount t (drawing 4 (a)). Next, it asks for total of the absolute value of a brightness difference with the aperture in time amount t in the image in time amount t+delta t, moving an aperture one point at a time in the direction of a radial from FOE. And the movement magnitude of an aperture when total becomes min is calculated as a velocity vector of one point to which its attention is paid (drawing 4 (b)). In addition, the above-mentioned brightness difference is a thing between the pixels of the corresponding location shown in (a) and (b) by O about each pixel which constitutes an aperture. It can ask for the optical flow of the whole image by performing the above processings repeatedly in all the points of the image of time amount t.
[0035] Moreover, by the conventional approach, when corresponding apertures were compared, the cross-correlation value was used. Since total of the absolute value of a brightness difference is used by the approach of this invention to it, it becomes mitigation of computational complexity and processing can be accelerated.
[0036] Further, it is asking for the velocity vector from not all the points in an image, and a difference is searched for and it is made to process by the image of time amount t and time amount t+delta t in this invention only to the point beyond the fixed threshold which is the difference.
[0037] Generally, the image which projected the foreground during car transit has many locations which do not have a time brightness change like empty or a road surface. Asking for an optical flow theoretically is impossible in such a location. Therefore, like the approach of this invention, within the image in time amount t, and the image in time amount t+delta t, if it is, it is accelerable by becoming possible to exclude useless processing by [which is a brightness difference] processing paying

attention to things.
[0038] A high speed is asked for an optical flow by approach which was mentioned above. However, the optical flow produced by what is not obstructions, such as scenery other than a road and a lane of a road surface, is contained in the optical flow which was able to be found here. Therefore, it is difficult to search for the danger by existence of a front obstruction or its obstruction using the optical flow currently called for here. Therefore, it is necessary to remove the optical flow produced from the scenery outside a road, or the lane of a road surface. Next, this approach is explained.
[0039] Drawing 5 is one example of the approach of removing the optical flow by the scenery outside a road. The location where the slash is drawn in this drawing shall not process in the other location noting that it shows a path on the street. by carrying out like this, since it begins, the optical flow produced from the scenery outside a road cannot be found -- ******** -- in addition -- and the processing time can be accelerated by restricting a field.
[0040] Next, how to erase the mark on a road surface is explained using drawing. Drawing 6 is one example of this approach, and explains an optical configuration first. Drawing 6 is drawn instead of the car which installed the video camera going straight on, assuming that the whole road surface has approached. The lens of the video camera with which 11 picturizes the front, and 12 show the image plane of a video camera. 13 and 14 express the lane before and behind migration. The three-dimension coordinate which makes the core of a lens a zero, and the two-dimensional coordinate which makes Above FOE a zero on the image plane 2 are considered.
[0041] The height to the video camera of the lane where the optical flow has produced the location of the lane before migration like [similitude ratio / of two square shapes / three] a formula (1) in P (X, Y, Z+deltaZ) and a Z direction if the location after deltaZ migration is set to Q (X, Y, Z) can be known.
Y=y2 delta Z/fdeltay .... (9)
The optical flow which height is in agreement with video camera quantity, that is, has produced by the mark on a road surface etc. is removable using this height information that was able to be found.
[0042] Here, deltaZ is the distance which advanced between time interval deltat of the image of two sheets, and it can ask for it by getting to know a car rate. It becomes possible to remove the optical flow produced from other than the front obstruction by processing which was explained above. Therefore, a front obstruction becomes possible [searching for the danger which shows how much it is risk] from the location and die length of the optical flow left behind now.
[0043] Next, how to search for danger is explained. Drawing 7 shows one example of this approach. If a configuration is explained first, each field of I -IV shows the distant place of a self-lane, the method of Kon of a self-lane, the distant place of a next door lane, and the method of Kon of a next door lane, respectively. Weighting of the danger is carried out for every area to total of the die length of the optical flow which exists in each field, and it is searched for here with this value that carried out weighting. Furthermore, the predetermined threshold is set up for every field, and if total of flow die length exceeds this threshold, it will be judged that the field beyond a threshold is dangerous. Number level setting of the threshold is carried out, and the level of danger can also be judged.
[0044] It becomes possible to be able to demand cautions from an operator by

sounding an alarm at the end according to the magnitude of the danger searched for. Moreover, it also enables which field to indicate whether how many to be risk on a display. It is also possible to change classes, such as a tone of an alarm, with risk level furthermore.

[0045] If the procedure of the image processing by the approach of this invention explained above is summarized and shown, it will become like drawing 8 . First, the image in time amount t is captured in step S1, and then the image in time amount t+delta t is captured in step S2. After that, FOE is set up in step S3 and a processing field is set up in continuing step S4. Then, it progresses to step S5 and the field where the brightness difference exceeded the fixed threshold by the image of time amount t and time amount t+delta t here is extracted. It asks for an optical flow in the field progressed and extracted to step S6 after that, an optical flow path on the street is removed in the following step S7, and danger is calculated with the value which carried out weighting for every area in the following step S8 further.

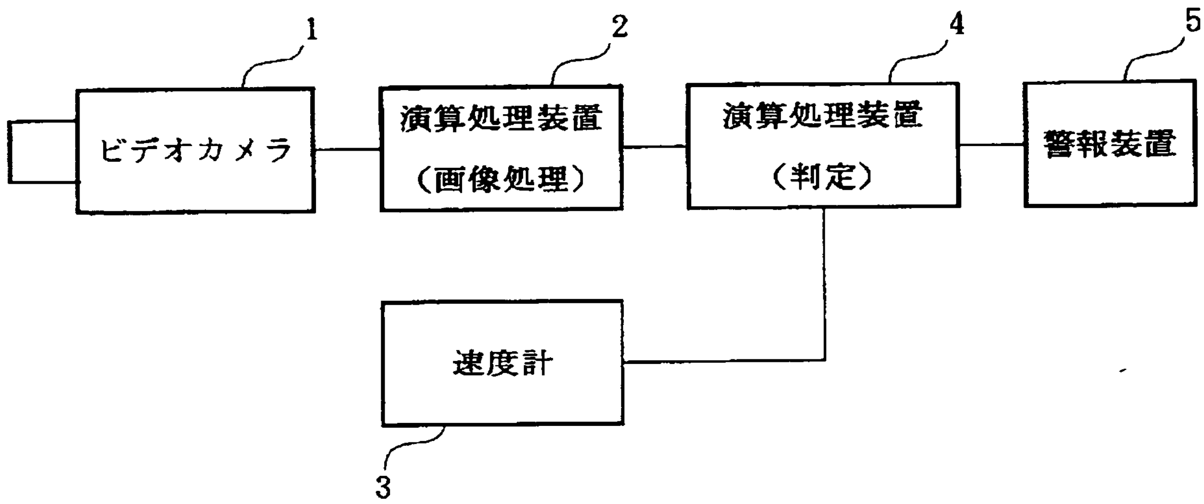
[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block diagram showing an example of the equipment for enforcing the approach by this invention.
[Drawing 2] It is drawing showing the foreground which the video camera of drawing 1 picturizes, an image, and the optical flow obtained.
[Drawing 3] It is drawing for explaining the method of detection, such as an obstruction by the approach of this invention.
[Drawing 4] It is drawing for explaining how asking for an optical flow by the approach of this invention.
[Drawing 5] It is drawing showing an example of the field set up in order that an optical flow might ask by the approach of this invention.
[Drawing 6] It is drawing for explaining the method of removal of the optical flow by the lane on a road surface by the approach of this invention.
[Drawing 7] It is drawing showing an example of the area divided in order to judge danger by the approach of this invention.
[Drawing 8] It is drawing showing a series of processings of the approach of this invention.
[Drawing 9] It is drawing for explaining the trouble of the conventional approach.
[Description of Notations]
1 Video Camera
2 Four Processing unit
5 Alarm

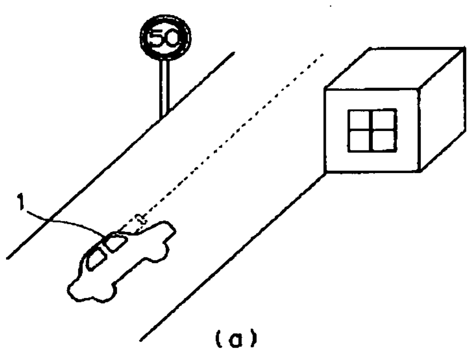
[Translation done.]

Drawing selection drawing 1

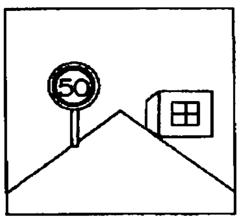


[Translation done.]

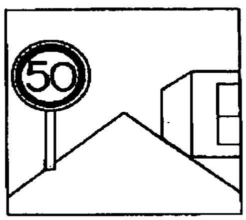
Drawing selection drawing 2



(a)

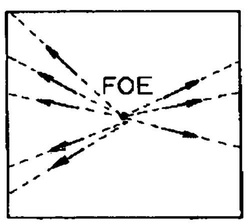


(b)



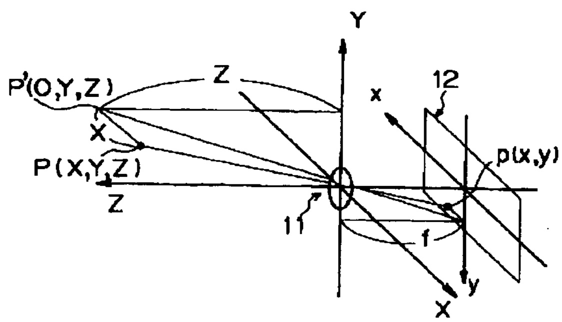
(c)

(d)



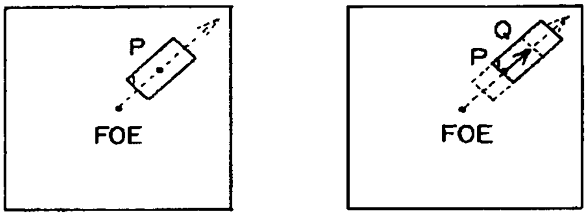
[Translation done.]

Drawing selection drawing 3



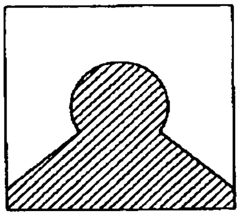
[Translation done.]

Drawing selection drawing 4



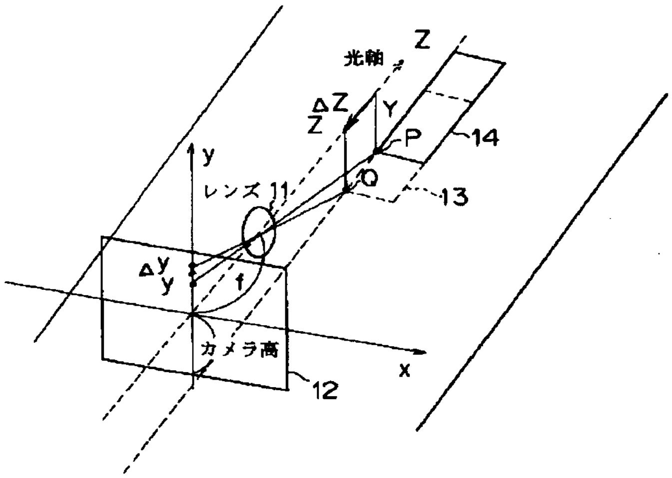
[Translation done.]

Drawing selection drawing 5



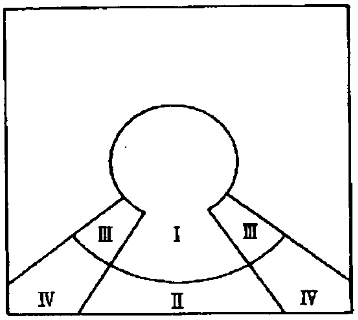
[Translation done.]

Drawing selection drawing 6



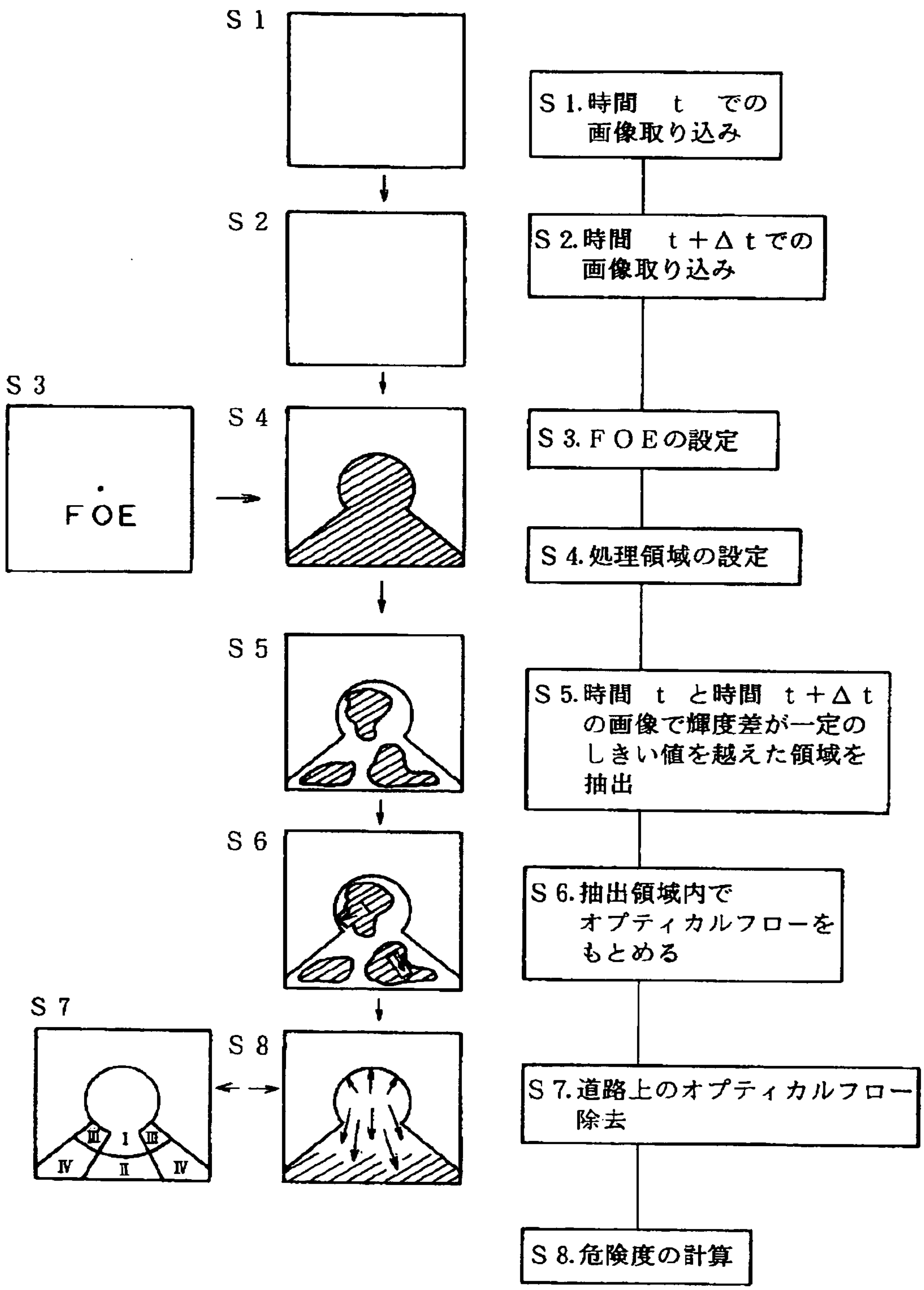
[Translation done.]

Drawing selection drawing 7



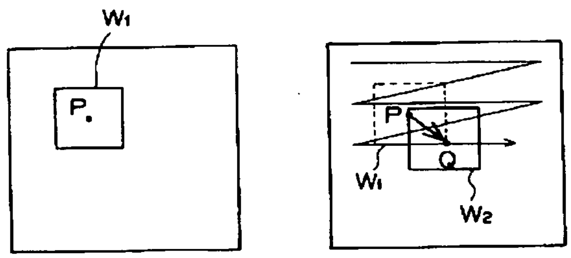
[Translation done.]

Drawing selection drawing 8



[Translation done.]

Drawing selection drawing 9



(a) (b)

[Translation done.]

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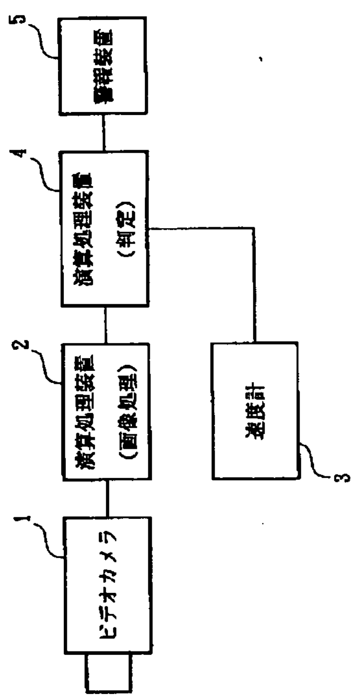
最終頁に続く

(54)【発明の名称】　車両用前方監視方法

(57)【要約】

【目的】　先行車両との車間距離を計測する距離センサを用いることなく、１台のビデオカメラによる前景画像を用いて、前方の走行車両や他の路上障害物による危険度を自動的にかつ高速に判定できる車両用前方監視方法を提供する。

【構成】　撮像した一連の前景動画像中の時間的に相前後する２コマの画像中に写し出される対象物体上の同一点の移動をオプティカルフローベクトルとして検出し、その大きさにより危険を判断する。前画像のＦＯＥから放射状の方向に設定した細長い窓を後画像上において同方向に移動し、該窓と該窓に重なる後画像上の領域の輝度差の絶対値の総和が最小になる窓の位置と該窓の前画像における設定位置とのそれぞれの中心点間を結ぶ矢印を着目する１点のオプティカルフローベクトルと定める。ただしオプティカルフローを求める点は前後画像の輝度差がある一定のしきい値を越えた点のみとし、オプティカルフローを求めるに当たって道路外の風景や路面上に描かれた車線や文字又は記号の影響を取り除く。



【特許請求の範囲】

【請求項１】　走行している自車両から前景を撮像し、所定時間相前後する２コマの画像中の同一点の移動をオプティカルフローとして検出し、自車両に対する先行車両又は路上障害物の相対関係を監視する車両用前方監視方法において、

前記先行車両又は路上障害物上の点に対して現れるオプティカルフローのベクトルの大小及び出現位置の如何によって危険度を判断することを特徴とする車両用前方監視方法。

【請求項２】　所定時間相前後する２コマの画像のうちの前の画像において、走行している自車両の進行方向を示す１点に対応する無限遠点から、着目する１点に対して放射状の方向に細長い窓を設定し、後の画像において該窓を前記無限遠点から放射方向に移動しながら、前記前の画像での窓と該窓に重なる後の画像の領域との輝度差の絶対値の総和を求め、該総和が最小になったときの窓の位置と該窓の前の画像における設定位置とのそれぞれの中心点間を結ぶ矢印を１点のオプティカルフローと定めることを特徴とする請求項１記載の車両用前方監視方法。

【請求項３】　所定時間相前後する２コマの画像間で各点の輝度差を求め、該輝度差がある一定のしきい値を越えている点についてのみオプティカルフローを求めることを特徴とする請求項１記載の車両用前方監視方法。

【請求項４】　オプティカルフローを求めるに当たって道路外の風景や路面上に描かれた車線や文字、記号などから生じるオプティカルフローを除去することを特徴とする請求項１記載の車両用前方監視方法。

【請求項５】　オプティカルフローを求めるに当たって走行予定車線外の風景に相当する領域を予め設定し、該設定した領域の処理を行わないことを特徴とする請求項１記載の車両用前方監視方法。

【請求項６】　走行している自車両から前景を撮像するビデオカメラを備え、オプティカルフロー情報をもとにオプティカルフローが生じている路面上の車線や文字、記号などからビデオカメラまでの高さを求め、該高さが路面からのカメラの高さと一致しているオプティカルフローを除去することを特徴とする請求項４記載の車両用前方監視方法。

【請求項７】　予め定めた領域を複数の区域に分け、各区域に存在するオプティカルフローベクトルの長さの総和に対して区域毎に重み付けし、該重み付けされた値の大小によって危険の度合を判断することを特徴とする請求項１記載の車両用前方監視方法。

【請求項８】　各区域毎に所定のしきい値を設定し、前記オプティカルフローの長さの総和が該しきい値を越えた区域を危険と判断することを特徴とする請求項７記載の車両用前方監視方法。

【請求項９】　前記しきい値が数レベルからなり、前記オプティカルフローの長さの総和が越えたしきい値のレベルにより危険度のレベルを判断することを特徴とする請求項８記載の車両用前方監視方法。

【請求項１０】　求められた危険度の大きさに従って警報を発することを特徴とする請求項９記載の車両用前方監視方法。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、自動車などの車両の前部に設置したビデオカメラによって撮像した画像を用いて、車両の走行の際に前方の車両又は障害物を検知し運転者に警告を与えるための車両用前方監視方法に関するものである。

【０００２】

【従来の技術】従来、この種の方法として、例えば特願平２－２４１８５５号公報に開示されたものがある。同公報に開示された方法は、走行している自車両から前景を撮影し、この撮影した前景の同一点の移動を所定時間毎にオプティカルフローとして認識し、このオプティカルフローと前方車両との車間距離を測定する距離センサをもとに自車両に対する先行車両の位置、相対速度からなる情報を得、この情報をもとに危険と判断した場合に運転者にその旨を知らせるものである。

【０００３】また、オプティカルフローを求めるために、従来、２コマの画像間で対応する点を検出するマッチング法と呼ばれる手法が採用されていた。このマッチング法は、図９（ａ）に示す時点ｔにおける画像上において着目する画素Ｐに対し窓Ｗ１をとり、画像内全域又は周辺の領域に対し窓を移動しながら相関値を計算し、図９（ｂ）に示すように、相関値が最大となった窓Ｗ２の点を対応点、すなわち対応する画素Ｑとして求め、このＰＱ（矢印）がオプティカルフローとなる。上記相関値を求めるためには、

$$\Sigma\left(W1_{(x,y)} \times W2_{(x,y)}\right) / \left(\Sigma W1^2_{(x,y)} \times \Sigma W2^2_{(x,y)}\right)^{1/2} \quad \cdots\cdots (1)$$

なる計算を行う。なお、$W1_{(x,y)}$，$W2_{(x,y)}$ は窓Ｗ１，Ｗ２内の（ｘ，ｙ）座標の出力である。

【０００４】

【発明が解決しようとする課題】しかし、このような従来の方法では、危険を判断するために、前景を撮影するビデオカメラに加え、自車両に対する先行車両の位置を知るために前方車両との車間距離を測定するための距離センサをも同時に必要としている。

【０００５】また、オプティカルフローを求めるために、２枚の画像間で対応する点を検出するという演算処理を行う必要があるが、上述したようにこの演算処理は、ある一点の対応点を検出するために、画像内の一画

素に対し、画像内の全領域あるいは周辺の領域の全ての画素に対して検索を行うといったものである。画像全体にわたって対応点を検出するためには、この処理を全画素に対して行わなければならない。また、検索を行うために指標として使用する相関値を求めるためにも多くの計算を必要とする。

【0006】従って、計算量が膨大になるため実時間化が困難であったり、実現するためには、高速度の演算処理装置を必要とするため装置自体が高価格化してしまうというような問題があげられる。また、オプティカルフローが、先行車両の部分から生じているものか、道路外の風景または路面上の文字や記号あるいは白線などから生じているものかといったことを区別することが困難であるという問題点もあげられる。

【0007】よって本発明は、上述した従来の問題点に鑑み、先行車両との間の距離を計測することなく、車両前部に設置したビデオカメラからの前景画像を用いて、前方の走行車両や他の障害物による危険度を自動的に判定できるようにした車両用前方監視方法を提供することを目的としている。

【0008】また本発明は、ビデオカメラで撮像した前景において、所定時間毎に同一点の移動をオプティカルフローとして高速に認識することができるようにした車両用前方監視方法を提供することを目的としている。

【0009】

【課題を解決するための手段】上記目的を達成するため本発明によりなされた車両用前方監視方法は、走行している自車両から前景を撮像し、この撮像した前景の同一点の移動を所定時間相前後する２コマの画像に基づいてオプティカルフローとして認識し、該オプティカルフローをもとに自車両に対する先行車両又は障害物を監視する車両用前方監視方法において、前記先行車両又は障害物上の点の前記オプティカルフローの大きさにより危険度を判断することを特徴としている。

【0010】上記車両用前方監視方法において、所定時間相前後する２コマの画像における前の画像において走行している自車両の進行方向を示す１点に対応する無限遠点から着目する１点に対して放射状の方向にその１点を中心とする細長い窓を設定し、後の画面において該窓を前記無限遠点から放射方向に移動しながら、前記前の画像での窓との輝度差の絶対値の総和を求め、該総和が最小になったときの窓の移動量を着目する１点のオプティカルフローとして求めることを特徴としている。

【0011】上記車両用前方監視方法において、所定時間相前後する２コマの画像で輝度差を求め、該輝度差がある一定のしきい値を越えた点についてオプティカルフローを求めることを特徴としている。

【0012】上記車両用前方監視方法において、オプティカルフローを求めるに当たって道路外の風景や路面の車線や文字、記号などから生じるオプティカルフローを除去することを特徴としている。

【0013】オプティカルフローを求めるに当たって道路外の風景に相当する領域を予め設定し、該設定した領域の処理を行わないことを特徴としている。

【0014】走行している自車両から前景を撮像するビデオカメラを備え、オプティカルフロー情報をもとにオプティカルフローが生じている路面上の車線や文字、記号などからビデオカメラまでの高さを求め、該高さが路面からのカメラの高さと一致しているオプティカルフローを除去することを特徴としている。

【0015】予め定めた領域を複数の区域に分け、各区域に存在するオプティカルフローベクトルの長さの総和に対して区域毎に重み付けし、この重み付けした値によって危険の度合を判断することを特徴としている。

【0016】各区域毎に所定のしきい値を設定し、前記重み付けされたオプティカルフローベクトル長さの総和が該しきい値を越えた区域を危険と判断することを特徴としている。

【0017】前記しきい値が数レベルからなり、前記重み付けされたオプティカルフロー長さの総和が越えたしきい値のレベルにより危険度のレベルを判断することを特徴としている。

【0018】求められた危険度の大きさに従って警報を発することを特徴としている。

【0019】

【作用】上記方法によれば、先行車両又は障害物との距離が小さい程、また相対速度が大きい程、オプィカルフローが大きくなることに着目して、先行車両又は路上障害物上の点のオプティカルフローの大きさにより危険を判断するようにしているので、格別先行車両との間の距離を測定するための距離計を設ける必要がなくなっている。

【0020】オプティカルフローが自車両の進行方向を示す１点に対応する無限遠点から放射状の方向に形成されることに着目して、２コマの画像のうちの前の画像において、走行している自車両の進行方向を示す１点に対応する無限遠点から、着目する１点に対して放射状の方向に細長い窓を設定し、後の画面において該窓を前記無限遠点から放射方向に移動しながら、前記前の画像での窓と該窓に重なるあとの画像の領域との輝度差の絶対値の総和を求め、該総和が最小になったときの窓の位置と該窓の前の画像における設定位置とのそれぞれの中心点間を結ぶ矢印を１点のオプティカルフローと定めるようにしているので、計算量の軽減となって処理の高速化が行える。

【0021】画像内に含まれる空や路面のように時間的な輝度変化のない場所があることに着目して、所定時間相前後する２コマの画像で輝度差を求め、該輝度差がある一定のしきい値を越えた点についてオプティカルフローを求めるようにしているので、オプティカルフローを

求める画像内の点の数が大幅に減少し、無駄な処理を省くことが可能となり高速化が行える。

【0022】オプティカルフローを求めるに当たって走行予定車線外の風景から生じているオプティカルフローを除去するために走行予定車線外の風景に相当する領域を予め設定し、該設定した領域の処理を行わないようにしているので、処理時間の高速化が行える。

【0023】走行している自車両から前景を撮像するビデオカメラを備え、オプティカルフロー情報を用いてオプティカルフローが生じている路面上の車線や文字、記号などからビデオカメラまでの高さを求め、該高さが路面からのカメラの高さと一致しているオプティカルフローを除去することにより、前方他車、障害物のみから生じているオプティカルフローだけを処理することができ、オプティカルフローを用いて危険度を知ることが可能になると共に、処理時間の高速化が行える。

【0024】予め定めた領域を複数の区域に分け、各区域に存在するオプティカルフローの長さの総和に対して区域毎に重み付けし、この重み付けした値によって危険の存在を判断しているので、どの位置に危険があるかを知ることができる。また、各区域毎に所定のしきい値を設定し、オプティカルフローベクトル長さの総和が該しきい値を越えた区域を危険と判断し区域毎に危険度をしることができる。更に、しきい値が数レベルからなり、オプティカルフローベクトル長さの総和が越えたしきい値のレベルにより危険度のレベルを判断し、求められた危険度の大きさに従って警報を発するようにしている。

【0025】

【実施例】以下、本発明の実施例を図面に基づいて説明する。図1は本発明による方法を実施するための装置の構成を示し、同図において、1は前景を撮像するビデオカメラ、2はビデオカメラ1によって得られた画像を入力し、後述する画像処理を行う演算処理装置、3は自車両の速度を計測する速度計、4は演算処理装置2の画像処理結果と速度計3から得られる自車両速度とを入力して危険度判定処理を行う演算処理装置、5は警報装置である。

【0026】図2は、ビデオカメラ1によって得られる前景画像の変化を説明するための図であり、（b）は（a）に示す自車両を含む状況においてビデオカメラ1が時間tで撮像した画像、（c）は時間t＋Δtで撮像した画像をそれぞれ示す。

【0027】今、自車両は平坦な道を直進しているとする。例えば（a）に示される道路標識及び建物に注目すると、時間の経過により時間t、時間t＋Δtにおいて、（b）、（c）に示されるような画像が得られる。この２枚の画像において対応する点を捜しそれらを結ぶと（d）に示されるような速度ベクトルが得られる。これがオプティカルフローである。

【0028】ここでこれらオプティカルフローは、画像内のＦＯＥ（Focus of Expansion）とよばれる１点から放射状に現れる。ＦＯＥとは、無限遠点又は消失点と呼ばれ、車両が直進している場合画像上において自車両の進行方向を示す１点に対応する。このように、自車両が走行している場合に求められるオプティカルフローは、ＦＯＥから放射状の方向である。ここで先行車両から発せられたオプティカルフローは、自車両に対する先行車両の位置、相対速度からなる情報を含んでおり、オプティカルフローが長い程危険度が高いと考えられる。

【0029】次に、その詳細を図３を参照して説明する。同図の光学的配置おいて、１１はビデオカメラのレンズ、１２はビデオカメラのイメージプレーン、fはレンズ１１からイメージプレーン１２までの距離、P（X，Y，Z）は先行車両又は障害物上の任意の１点、p（x，y）はイメージプレーン１２上の点Pに対応する点とすると、３角形の相似の比から

$$x = f \cdot X / Z \quad \cdots\cdots (2)$$

となる。

【0030】この式を変形して、時間微分すると、

$$X' = (\Delta x / \Delta t \cdot Z + x \cdot Z') / f \quad \cdots\cdots (3)$$

となる。また、オプティカルフローのx方向成分uとは

$$u = \Delta x / \Delta t \quad \cdots\cdots (4)$$

であるので、これを用いて

$$Z = (f \cdot X' - x \cdot Z') / u \quad \cdots\cdots (5)$$

となる。

【0031】ここで

$$Z' = \text{先行車両ないし障害物と自車両との相対速度} = -\alpha \quad \cdots\cdots (6)$$

であるから上式（5）は

$$Z = (f \cdot X' + x\alpha) / u \quad \cdots\cdots (7)$$

となる。よってオプティカルフローのx方向成分uは

$$u = (f \cdot X' + x\alpha) / Z \quad \cdots\cdots (8)$$

となる。Yについても同様に求まる。

【0032】よって上式（8）より、Zが小、すなわち先行車両又は障害物までの距離が小である程、又はαが大、すなわち先行車両との相対速度が大である程、オプティカルフローのx成分は大きくなる。これはY方向についても同様である。従って、オプティカルフローは先行車両などとの距離が小な程、更に相対速度が大な程長くなり、これよりオプティカルフローが短いときより長

いときの方が相対的に先行車両又は障害物に対する危険度が大きいと考えられる。

【0033】本発明では、オプティカルフローがＦＯＥから放射状の向きに求められるということを利用し、高速にオプティカルフローを求めるようにしており、その方法を図４に基づいて以下説明する。

【0034】図４は、高速にオプティカル・フローを求める方法の一実施例を示した図である。まず、始めに時間ｔでの画像において着目する一点に対しＦＯＥから放射状の方向に細長い窓を設定する（図４（ａ））。次に、時間ｔ＋Δｔでの画像において、窓をＦＯＥから放射状の方向に一点づつ移動しながら、時間ｔでの窓との輝度差の絶対値の総和を求める。そして総和が最小になったときの窓の移動量が、着目する一点の速度ベクトルとして求められる（図４（ｂ））。なお、上記輝度差は、窓を構成する各画素について、例えば（ａ）及び（ｂ）に○で示す対応する位置の画素間のものである。以上のような処理を時間ｔの画像の全ての点において繰り返し行うことにより、画像全体のオプティカルフローを求めることができる。

【0035】また、従来の方法では、対応する窓同士を比べる際に、相互相関値を用いていた。それに対し本発明の方法では、輝度差の絶対値の総和を用いているので、計算量の軽減となり、処理の高速化が行える。

【0036】本発明では更に、画像内の全ての点に対し速度ベクトルを求めているのではなく、時間ｔと時間ｔ＋Δｔとの画像で差を求め、その差である一定のしきい値を越えた点だけに対し処理を行うようにしている。

【0037】一般に、車両走行中に前景を映した画像には、空や路面のように時間的な輝度変化がない場所が多い。このような場所では、原理的にオプティカルフローを求めることが不可能である。従って、本発明の方法のように、時間ｔでの画像と時間ｔ＋Δｔでの画像内で、輝度差のあるとことに着目して処理を行うことにより、＊無駄な処理を省くことが可能となり高速化が行える。

【0038】上述したような方法によって、高速にオプティカルフローが求められる。しかし、ここで求まったオプティカルフローには、道路以外の風景や路面の車線などの障害物ではないものによって生じているオプティカルフローが含まれている。従って、ここで求められているオプティカルフローを用いて前方の障害物の存在又はその障害物による危険度を求めることは困難である。よって、道路外の風景や路面の車線から生じているオプティカルフローを除去する必要がある。次に、この方法について説明する。

【0039】図５は、道路外の風景によるオプティカルフローを除去する方法の一実施例である。同図において斜線が引かれている位置が、道路上を示しているとして、それ以外の場所では、処理を行わないものとする。こうすることにより、始めから道路外の風景から生じるオプティカルフローは求まらないことになり、なおかつ領域を制限することにより、処理時間の高速化が行えることとなる。

【0040】次に、路面上のマークを消す方法について図を用いて説明する。図６はこの方法の一実施例であり、まず光学的構成を説明する。図６はビデオカメラを設置した車両が直進する代わりに、路面全体が近づいてきたと仮定して描かれている。１１は前方を撮像するビデオカメラのレンズ、１２はビデオカメラのイメージプレーンを示す。１３及び１４は移動前後の車線を表している。レンズの中心を原点とする３次元座標と、イメージプレーン２上で上記ＦＯＥを原点とする２次元座標を考える。

【0041】移動前の車線の位置をＰ（Ｘ，Ｙ，Ｚ＋ΔＺ）、Ｚ方向にΔＺ移動後の位置をＱ（Ｘ，Ｙ，Ｚ）とすると、２つの３角形の相似比より式（１）のようにオプティカルフローの生じている車線のビデオカメラまでの高さを知ることができる。

$$Y = y^2 \ \Delta Z / f \Delta y \quad \cdots\cdots (9)$$

この求まった高さ情報を用いて、高さがビデオカメラ高と一致している、つまり路面上のマークなどによって生じているオプティカルフローを除去することができる。

【0042】ここで、ΔＺは２枚の画像の時間間隔Δｔの間に前進した距離であり、車両速度を知ることにより求めることができる。以上説明したような処理によって、前方の障害物以外から生じているオプティカルフローを除去することが可能となる。従って、いま残されているオプティカルフローの位置及び長さから前方の障害物がどの程度危険であるかを示す危険度を求めることが可能となる。

【0043】次に、危険度を求める方法について説明する。図７はこの方法の一実施例を示すものである。まず構成を説明すると、Ｉ～IVの各領域はそれぞれ自車線の遠方、自車線の近方、隣車線の遠方、隣車線の近方を示している。ここで危険度は、各領域に存在するオプティカルフローの長さの総和に対して各区域毎に重み付けし、この重み付けした値によって求められる。更に、各領域毎に所定のしきい値を設定しておき、フロー長さの総和がこのしきい値を越えたらしきい値を越えた領域は危険と判断される。しきい値を数レベル設定しておき、危険度のレベルを判断することもできる。

【0044】最後に、求められた危険度の大きさに従って警報を鳴らすことによって運転者に対し注意を促せることが可能となる。また、ディスプレイ上にどの領域がどの程度危険かを表示することも可能になる。さらに危険レベルにより警報の音色などの種類を変えることも可能である。

【0045】以上説明した本発明の方法による画像処理の手順を要約して示すと、図８のようになる。まず、ス

テップＳ１において時間ｔでの画像を取り込み、次にステップＳ２において時間ｔ＋Δｔでの画像を取り込む。その後ステップＳ３においてＦＯＥの設定を行い、続くステップＳ４において処理領域の設定を行う。続いてステップＳ５に進み、ここで時間ｔと時間ｔ＋Δｔの画像で輝度差が一定のしきい値を越えた領域を抽出する。その後ステップＳ６に進んで抽出した領域内でオプティカルフローを求め、次のステップＳ７において道路上のオプティカルフローを除去し、更に次のステップＳ８において各区域毎に重み付けした値によって危険度を計算する。

【００４６】

【発明の効果】以上説明したように本発明によれば、前方障害物の存在又はその危険度を自動的に判断できるため、車両の安全運転が可能となる。

【００４７】特に、先行車両又は障害物上の点のオプティカルフローの大きさにより危険を判断するようにしていて、走行している自車両から前景を撮像するビデオカメラを１台前方に設置し、格別先行車両との間の距離を測定するための距離計を設ける必要がなくなっているので、低コストで実現可能である。

【００４８】また、計算量の軽減、無駄な処理を省略、処理領域の制限などにより、処理の高速化が行え、実時間処理が容易になる。

【００４９】更に、危険区域及びその度合いを知って適切な警報を発することができるなどの効果が得られる。

【図面の簡単な説明】

【図１】本発明による方法を実施するための装置の一例を示すブロック図である。

【図２】図１のビデオカメラが撮像する前景、画像及び得られるオプティカルフローを示す図である。

【図３】本発明の方法による障害物などの検出の仕方を説明するための図である。

【図４】本発明の方法によりオプティカルフローの求め方を説明するための図である。

【図５】本発明の方法によりオプティカルフローの求めるため設定した領域の一例を示す図である。

【図６】本発明の方法により路面上の車線によるオプティカルフローの除去の仕方を説明するための図である。

【図７】本発明の方法により危険度を判定するため分けた区域の一例を示す図である。

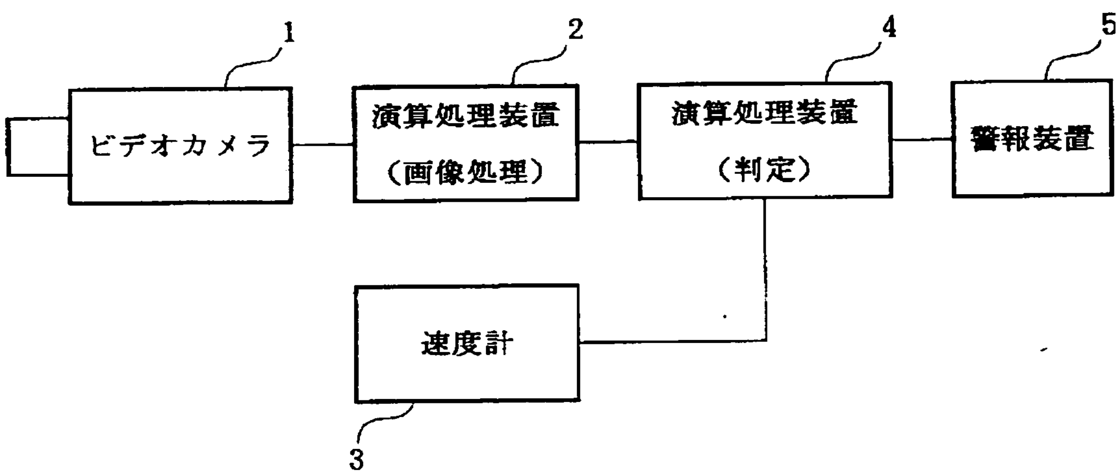
【図８】本発明の方法の一連の処理を示す図である。

【図９】従来の方法の問題点を説明するための図である。

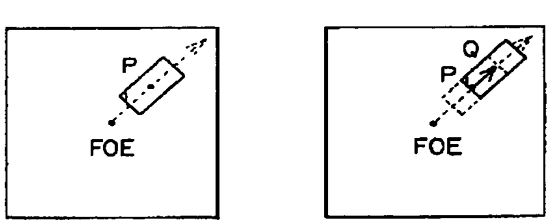
【符号の説明】

１	ビデオカメラ
２，４	演算処理装置
５	警報装置

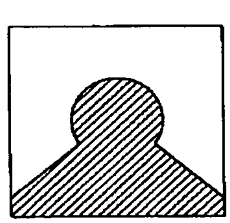
【図１】



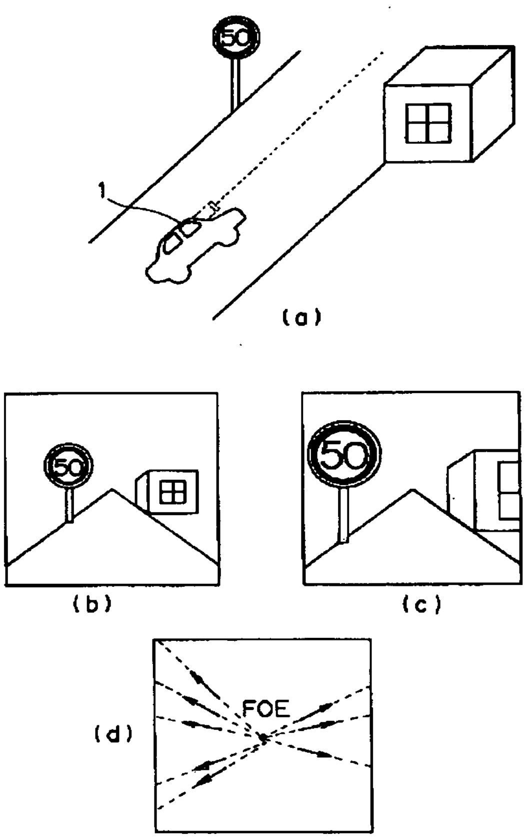
【図４】



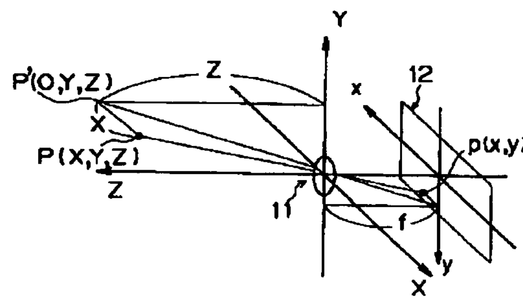
【図５】



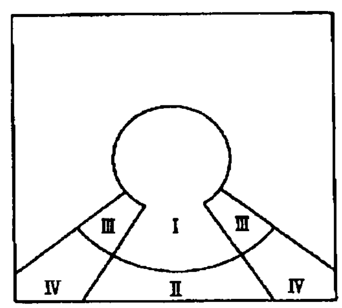
【図2】


50
1
(a)
50
(b)
50
(c)
(d)
FOE

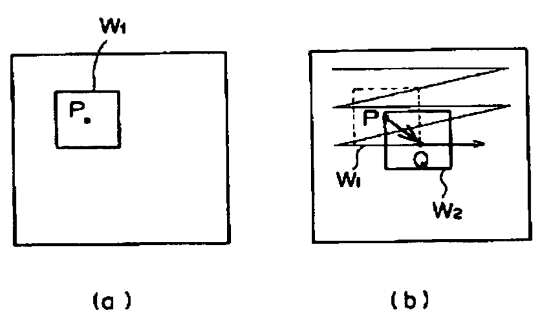
【図3】


Y
Z
12
x
P'(O,Y,Z)
X
P(X,Y,Z)
p(x,y)
Z
11
f
y
X

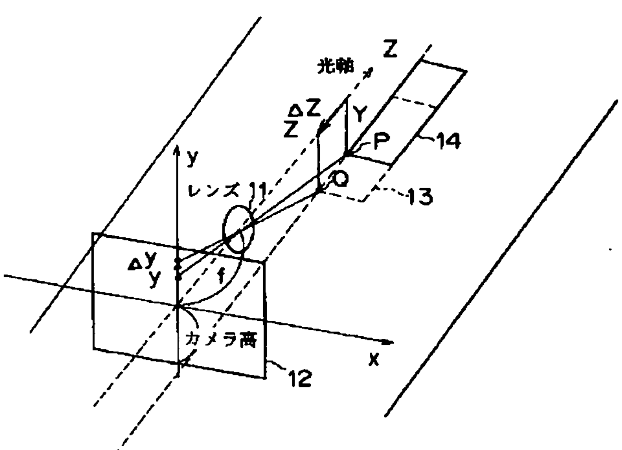
【図7】


I
II
III
III
IV
IV

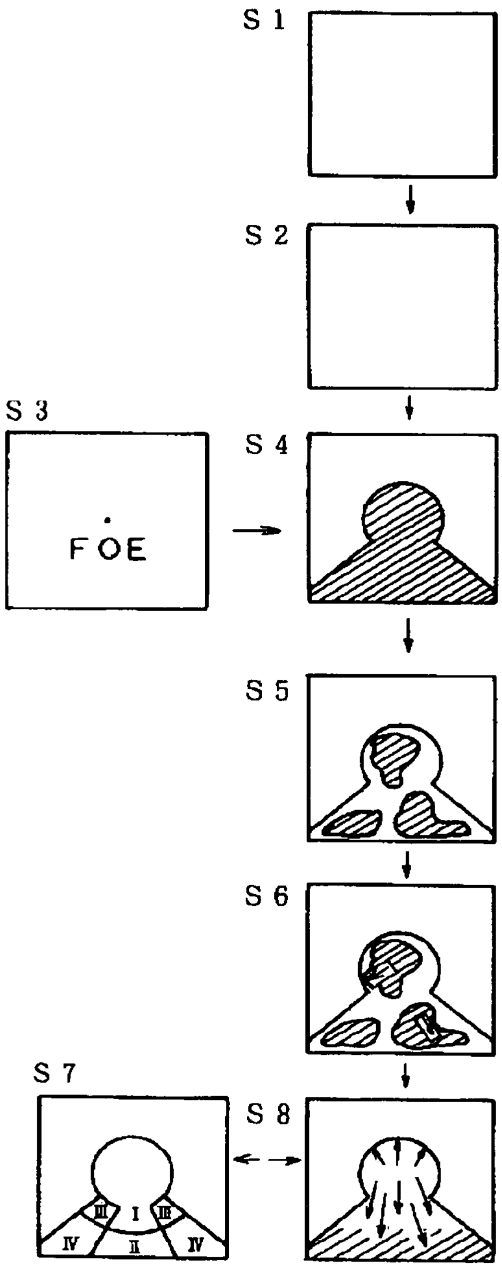
【図9】


W1
P
P
Q
W1
W2
(a)
(b)

【図6】


光軸
Z
ΔZ
Z
Y
P
14
Q
13
y
レンズ 11
Δy
y
f
カメラ高
x
12

【図8】



S 1. 時間　t　での画像取り込み

S 2. 時間　t＋Δtでの画像取り込み

S 3. FOEの設定

S 4. 処理領域の設定

S 5. 時間　t　と時間　t＋Δtの画像で輝度差が一定のしきい値を越えた領域を抽出

S 6. 抽出領域内でオプティカルフローをもとめる

S 7. 道路上のオプティカルフロー除去

S 8. 危険度の計算

【手続補正書】
【提出日】平成5年5月12日
【手続補正1】
【補正対象書類名】明細書
【補正対象項目名】００４１
【補正方法】変更
【補正内容】＊

＊【００４１】移動前の車線の位置をＰ（Ｘ，Ｙ，Ｚ）、Ｚ方向にΔＺ移動後の位置をＱ（Ｘ，Ｙ，Ｚ－ΔＺ）とすると、２つの３角形の相似比より式（１）のようにオプティカルフローの生じている車線のビデオカメラまでの高さを知ることができる。

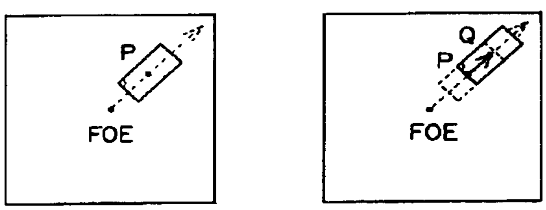
$$Y = y^2\ \Delta Z / f \Delta y \qquad \cdots\cdots (9)$$

この求まった高さ情報を用いて、高さがビデオカメラ高と一致している、つまり路面上のマークなどによって生※

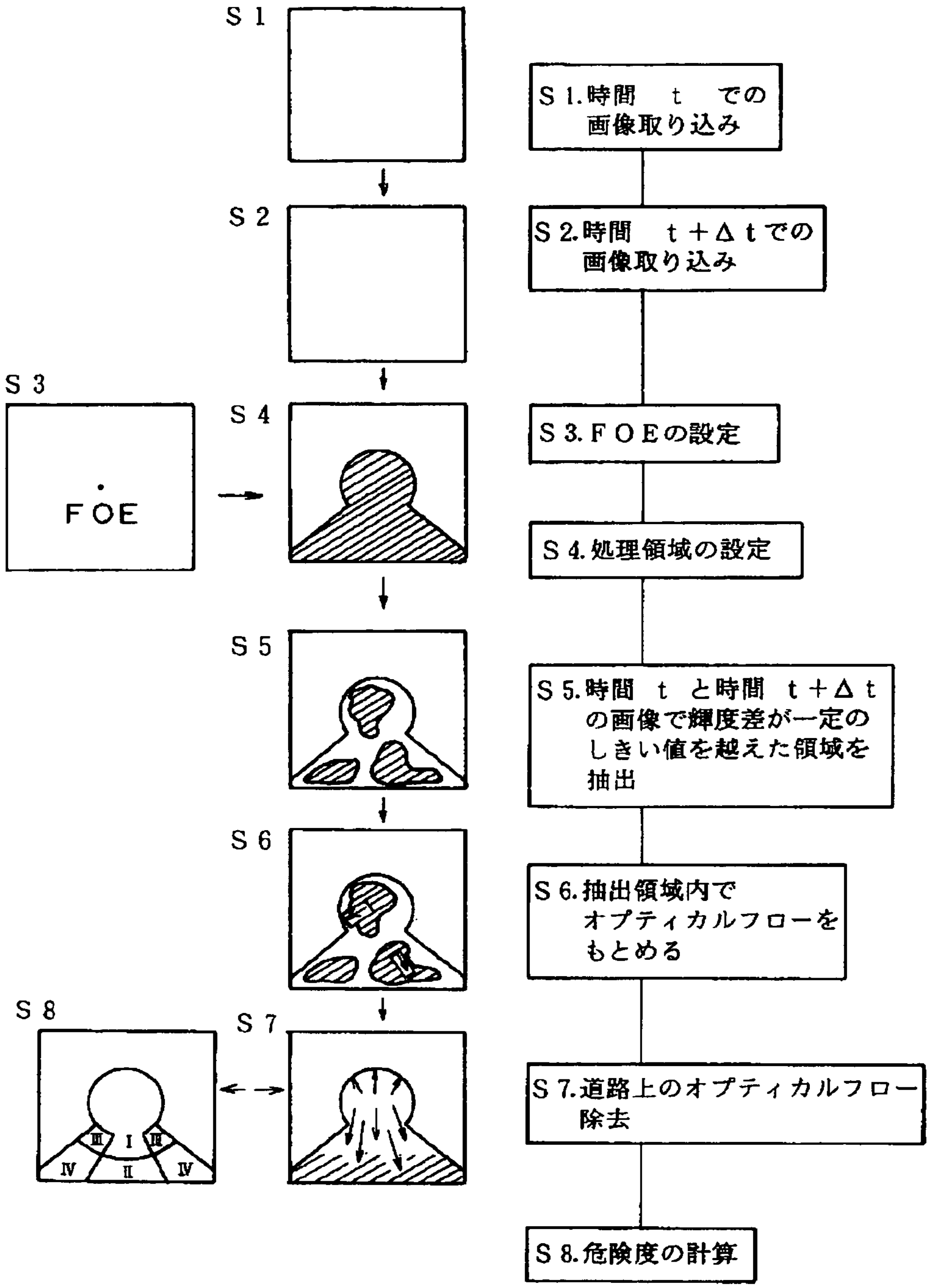
※じているオプティカルフローを除去することができる。

【手続補正書】
【提出日】平成5年5月12日
【手続補正1】
【補正対象書類名】図面
【補正対象項目名】図４
【補正方法】変更
【補正内容】
【図４】

(a)　　　　(b)



【手続補正2】
【補正対象書類名】図面
【補正対象項目名】図８
【補正方法】変更
【補正内容】
【図８】



フロントページの続き

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